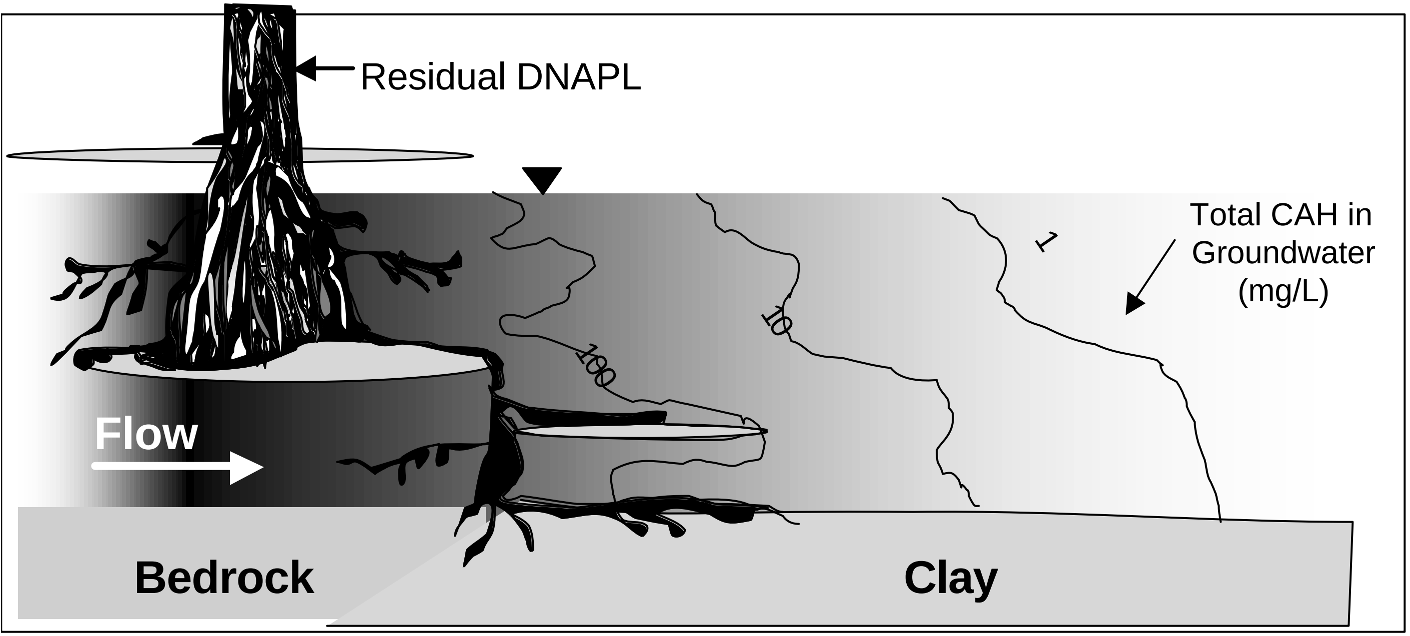
Innovative Technologies for DNAPL Treatment



Hans Stroo
SERDP / ESTCP
25 February 2003

THE DNAPL CHALLENGE

1. DNAPL Physical and Chemical Characteristics Complicate Discovery and Cleanup

2. Environmental Benefits of Removal Debatable

3. Removal / Destruction is Expensive

4. Limited Tools for Characterization or Assessment

5. Public Wants Treatment

DNAPLS: The DoD Challenge

DoD Has Approx. 3,000 Solvent Sites

Navy Estimates Cleanup Costs for 2001-2015 at $1.8b For 867 CAH Sites

DoD Pump-and-Treat Costs Exceed $100M Annually, with Life Cycle Costs > $2B

Sources Often Dispersed and Difficult to Locate

Source Removal Is Controversial

Mass Flux: A Difficult Metric

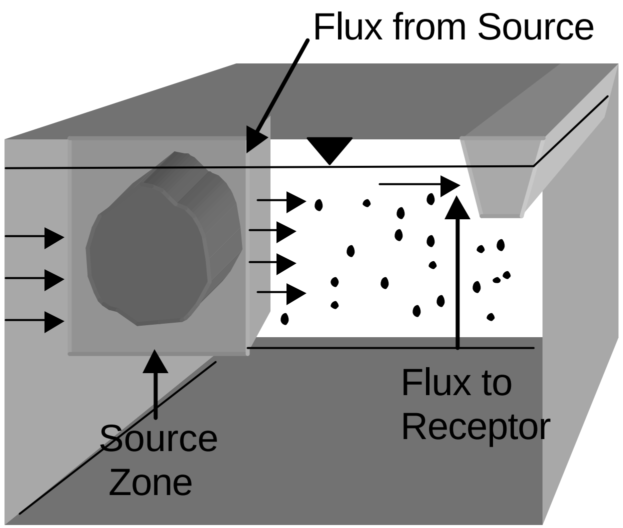
MCLs Not Achievable In Most Cases

Mass Flux Difficult to Measure Accurately

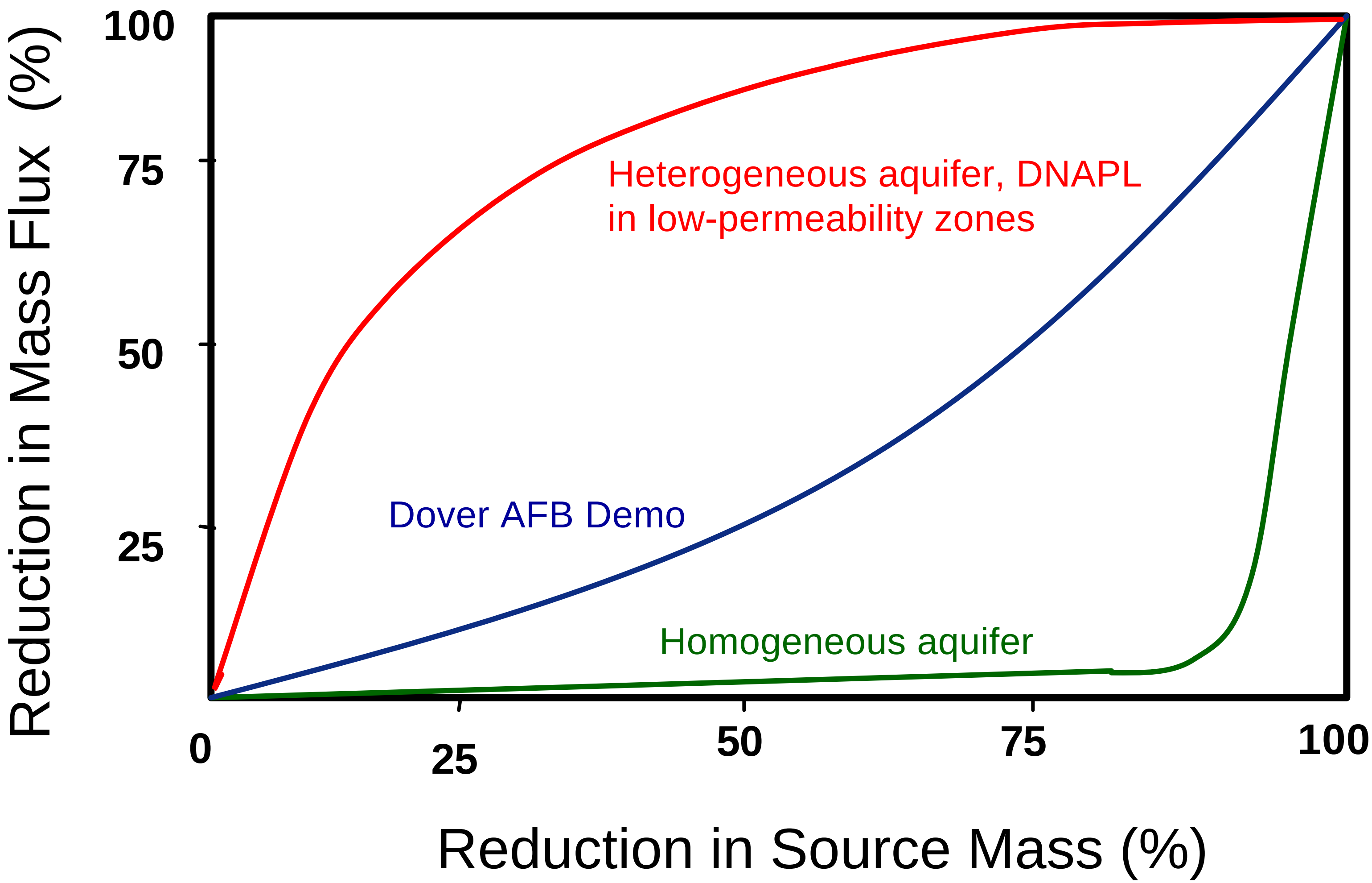
Can We Regulate on the Basis of A “Flux”?

Effect of Partial Source Removal on Mass Flux Difficult to Predict

Natural Attenuation Capacity Is Difficult to Evaluate



Mass Flux vs. Source Depletion



SOURCE DEPLETION TECHNOLOGIES

In Situ Chemical Oxidation

Surfactant Flushing

Alcohol or Cosolvent Flushing

In Situ Air Sparging / SVE

In Situ Thermal Treatment

In Situ Bioremediation

SOURCE DEPLETION TECHNOLOGIES
Advantages and Limitations

TECHNOLOGY	ADVANTAGES	LIMITATIONS
BIOREMEDIATION	All Treatment *In Situ* Low Capital & Energy Needs Moderate Cost	Relatively Slow Unproven Performance
IN SITU CHEMICAL OXIDATION	Rapid Source Depletion Little Secondary Waste	Competition for Oxidants Large Volumes for DNAPL
ENHANCED FLUSHING	Moderate Cost Compatible With MNA	Secondary Wastes Low Permeability Sites Hard May Be Expensive
ELECTRICAL RESISTANCE HEATING	Rapid Source Depletion High Mass Removals Suited for Low Permeabilities	Energy Intensive Expensive Secondary Wastes
STEAM INJECTION	Rapid Source Depletion Suited for Low Permeabilities	Energy Intensive Expensive Secondary Wastes

FIELD DEMO RESULTS

Technology	Location	Mass Loss
Surfactant Flushing	Dover AFB	61%
Surfactant Flushing	Camp Lejeune	60-70%
Surfactant Flushing	Hill AFB	Up to 98%
Cosolvent Flushing	Dover AFB	64%
Cosolvent Flushing	Jacksonville, FL	62-65%
In Situ Air Sparging	Dover AFB	59%
In Situ Oxidation	Cape Canaveral	62-84%
Six-Phase Heating	Cape Canaveral	90%
DUS/HPO	Visalia, CA	Uncertain

KEY R&D NEEDS

- Emphasize Source Zone Treatment
- Evaluate True Cost & Performance
- Improved Performance Assessment Tools
- Improved Measurements of Source Mass and Mass Flux
- Focus On Existing Technologies

SERDP DNAPL PROJECTS

Decision Support System to Evaluate Effectiveness and Cost of Source Zone Treatment

Development of Assessment Tools for Evaluation of the Benefits of DNAPL Source Zone Treatment

Mass Transfer from Entrapped DNAPL Source Areas Undergoing Remediation: Characterization Methods and Prediction Tools

Experimental and Modeling Assessment of the Benefits of Partial Source Removal

Diagnostic Tools to Evaluate Source Zone Treatment

ESTCP DNAPL Projects

Biodegradation of DNAPLs through Bioaugmentation of Source Areas

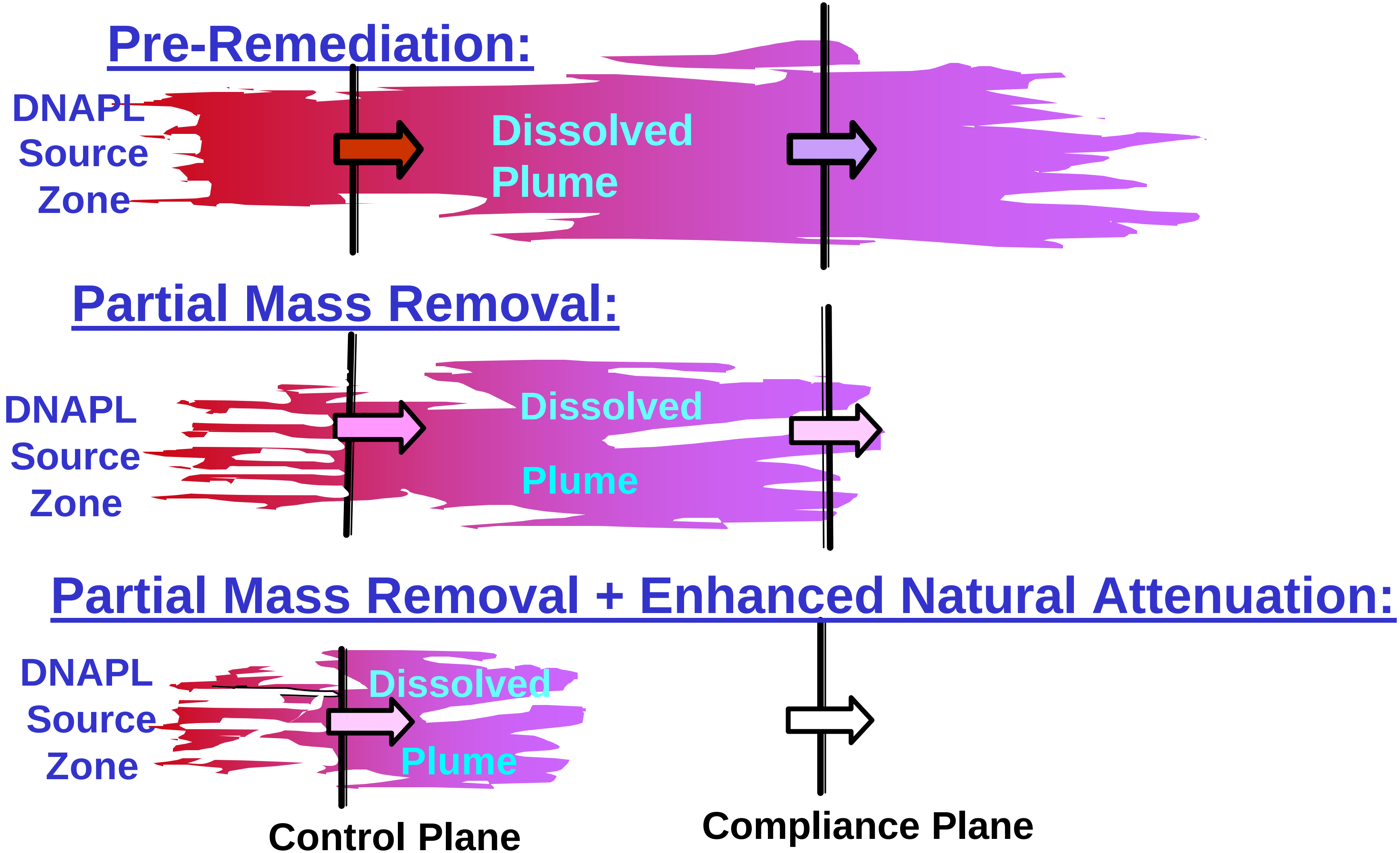
Remediation of DNAPLs through Sequential ISCO and Bioaugmentation

In Situ Bioremediation of Chlorinated Solvent Source Areas with Enhanced Mass Transfer

In Situ Thermal Treatment Demonstration (DUS/HPO): Beale AFB

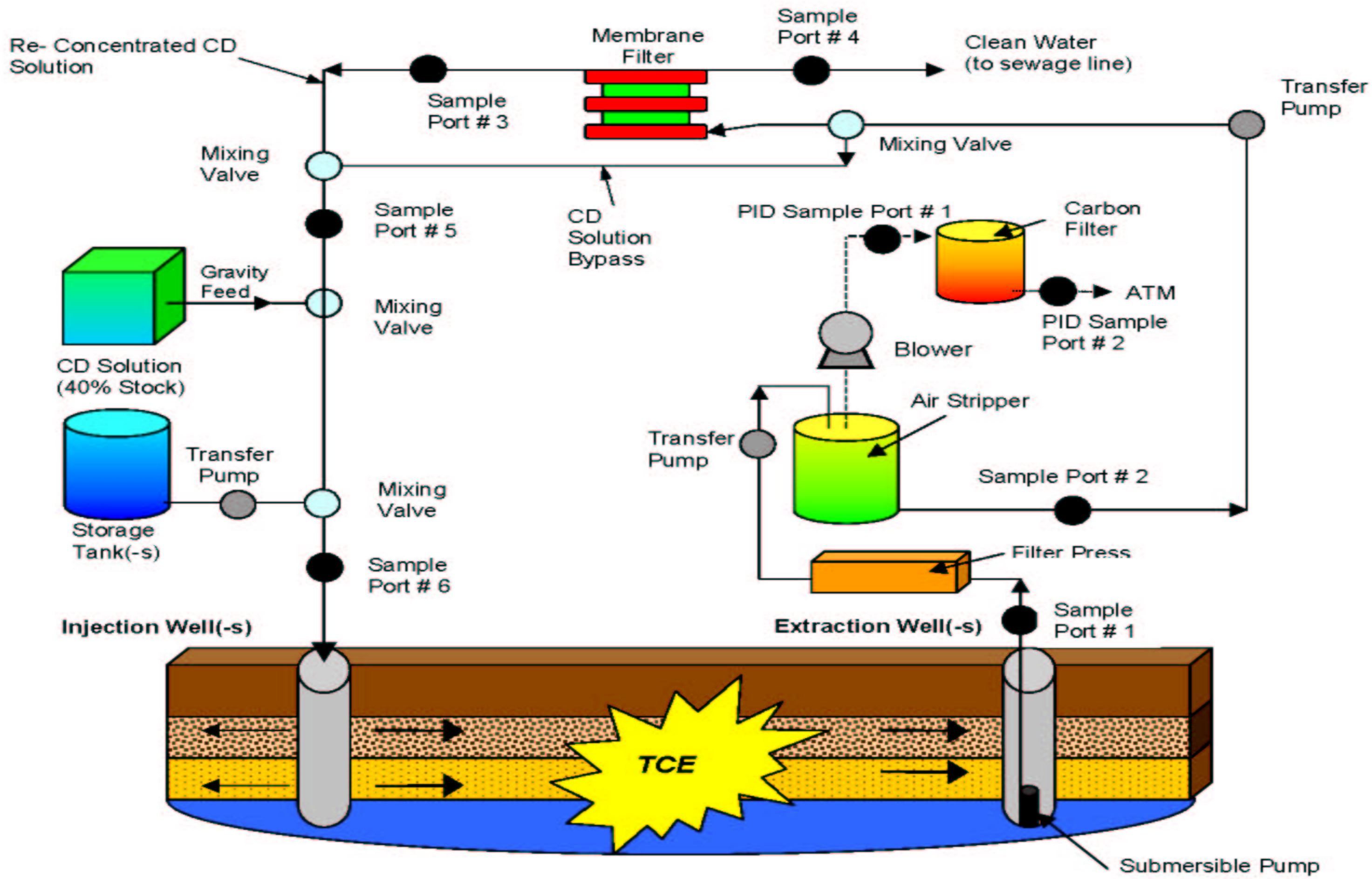
BENEFITS OF PARTIAL MASS REMOVAL

L. Wood, EPA



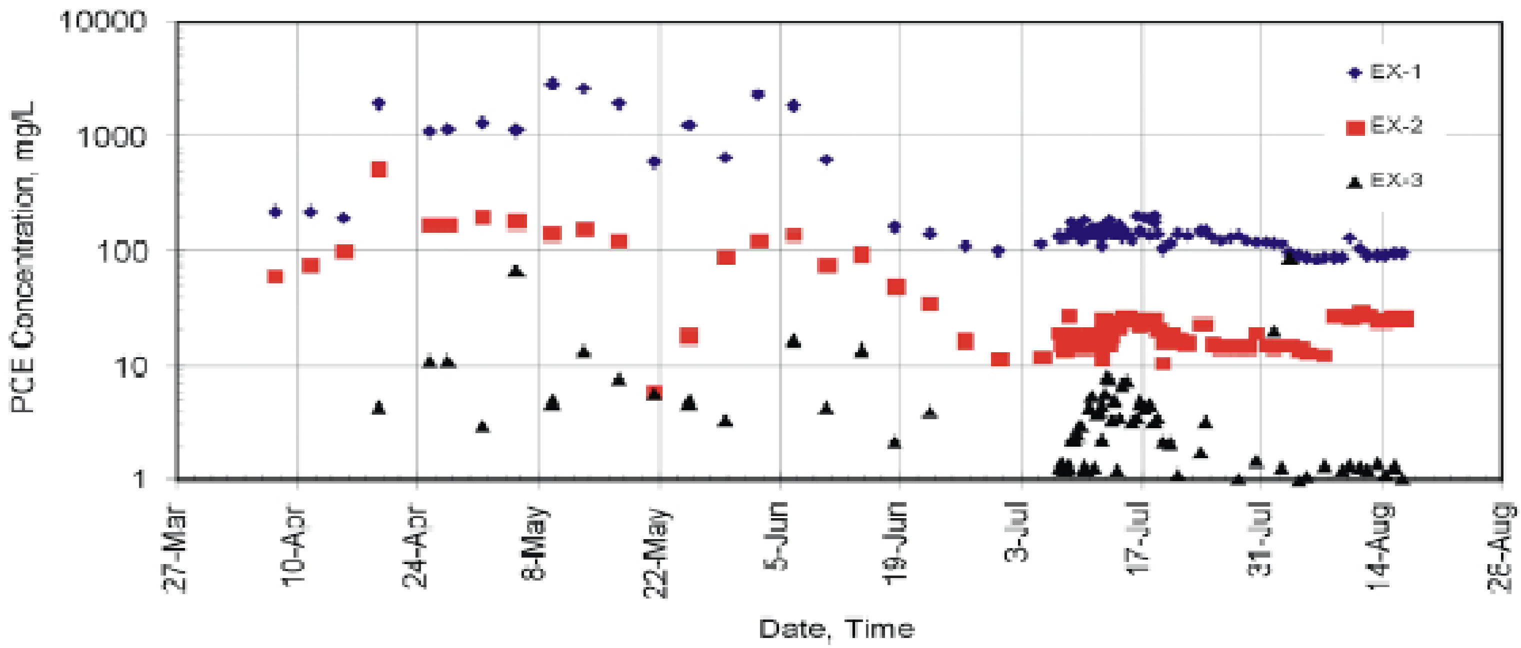
CYCLODEXTRIN EXTRACTION DEMO

T. Boving, University of Rhode Island



Surfactant Enhanced Aquifer Remediation

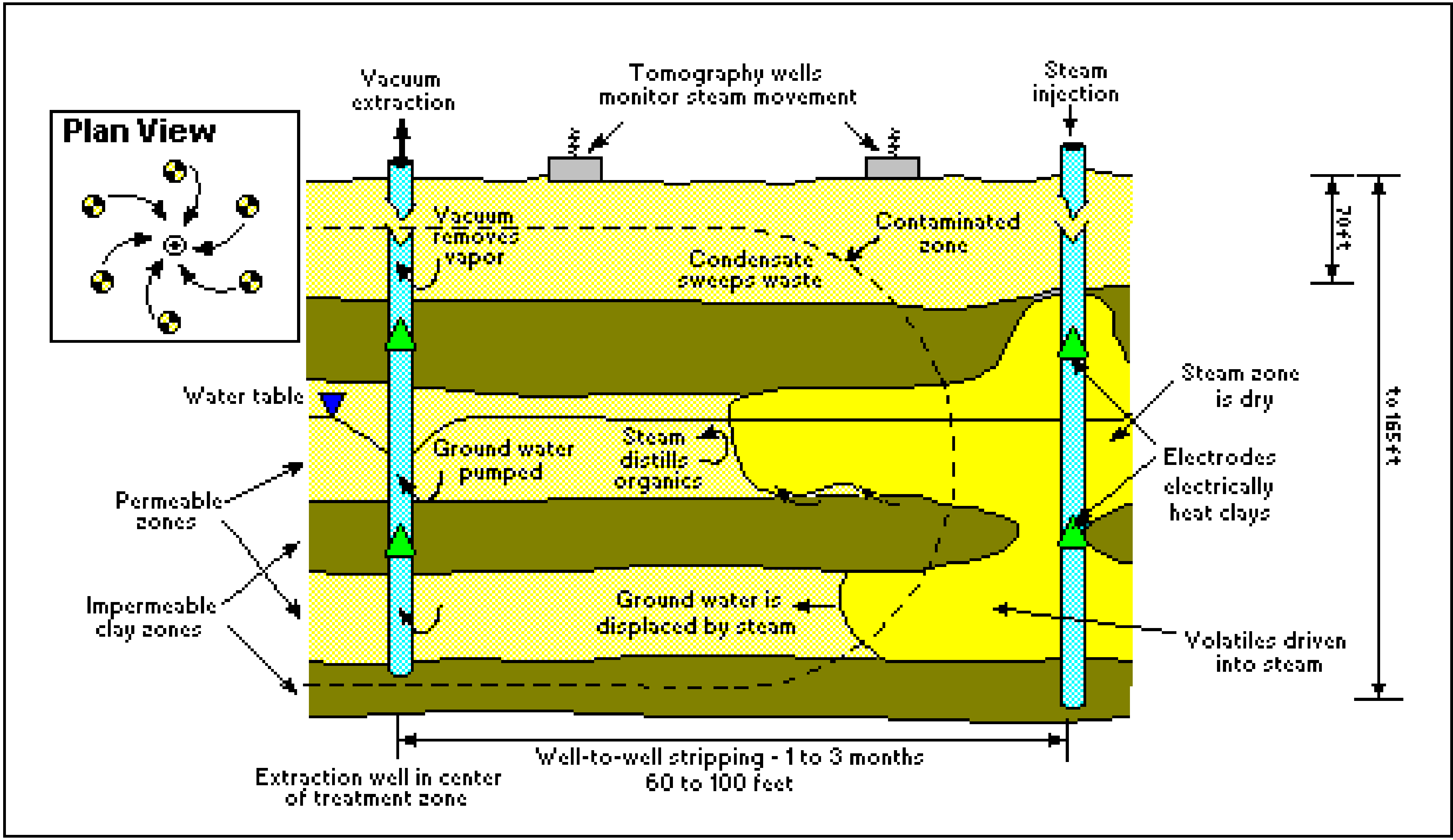
L. Yeh, NFESC



DATE: 1/5/00 REF: FILE: Spc 7 plots.bpt	History of PCE Concentrations in Extraction Wells EX01, EX02, and EX03
Duke Engineering & Services	Site 88, MCB Camp Lejeune, NC

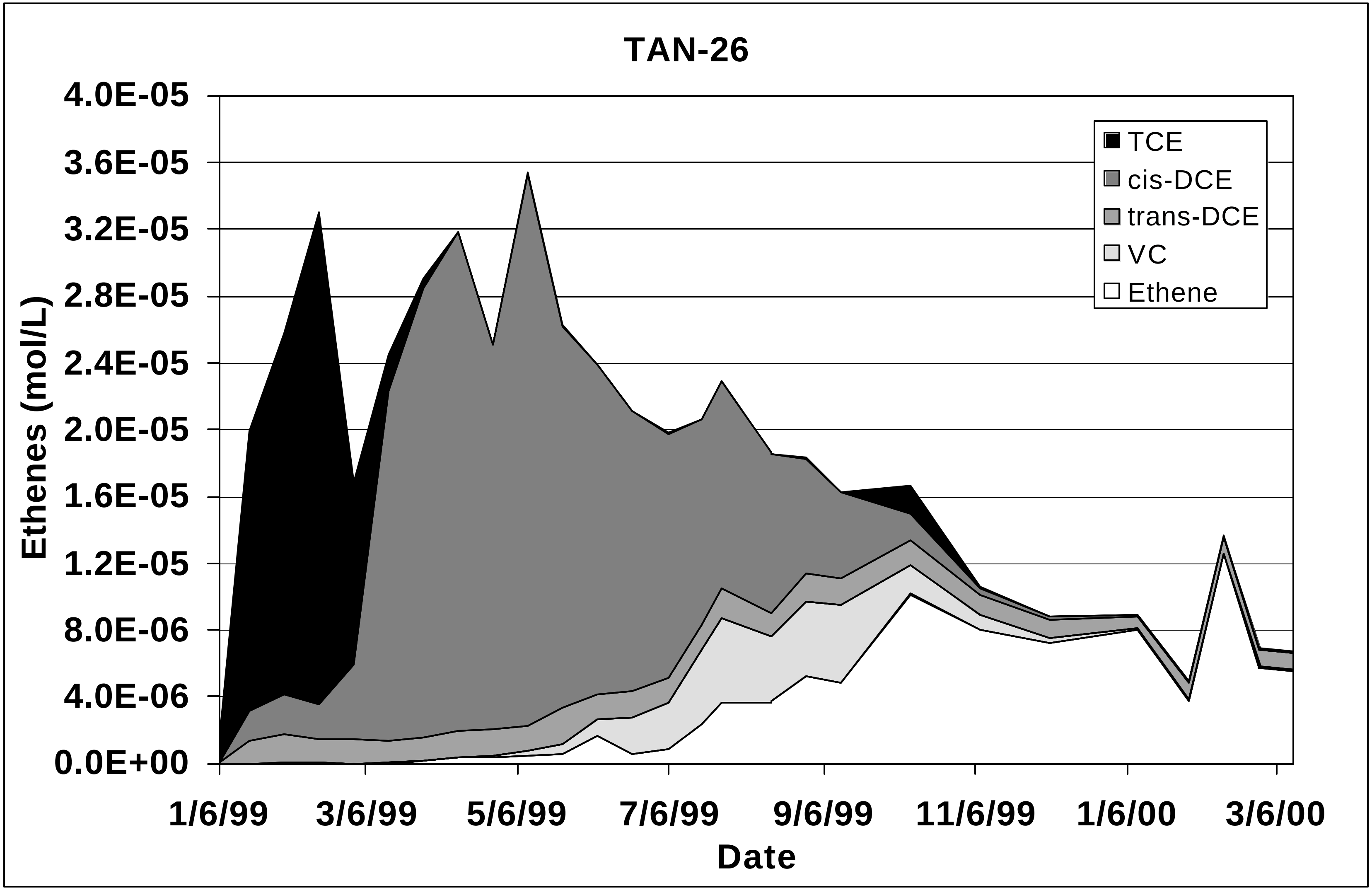
Figure 3.1. History of PCE Concentrations in Extraction Wells EX01, EX02, and EX03.

Dynamic Underground Stripping



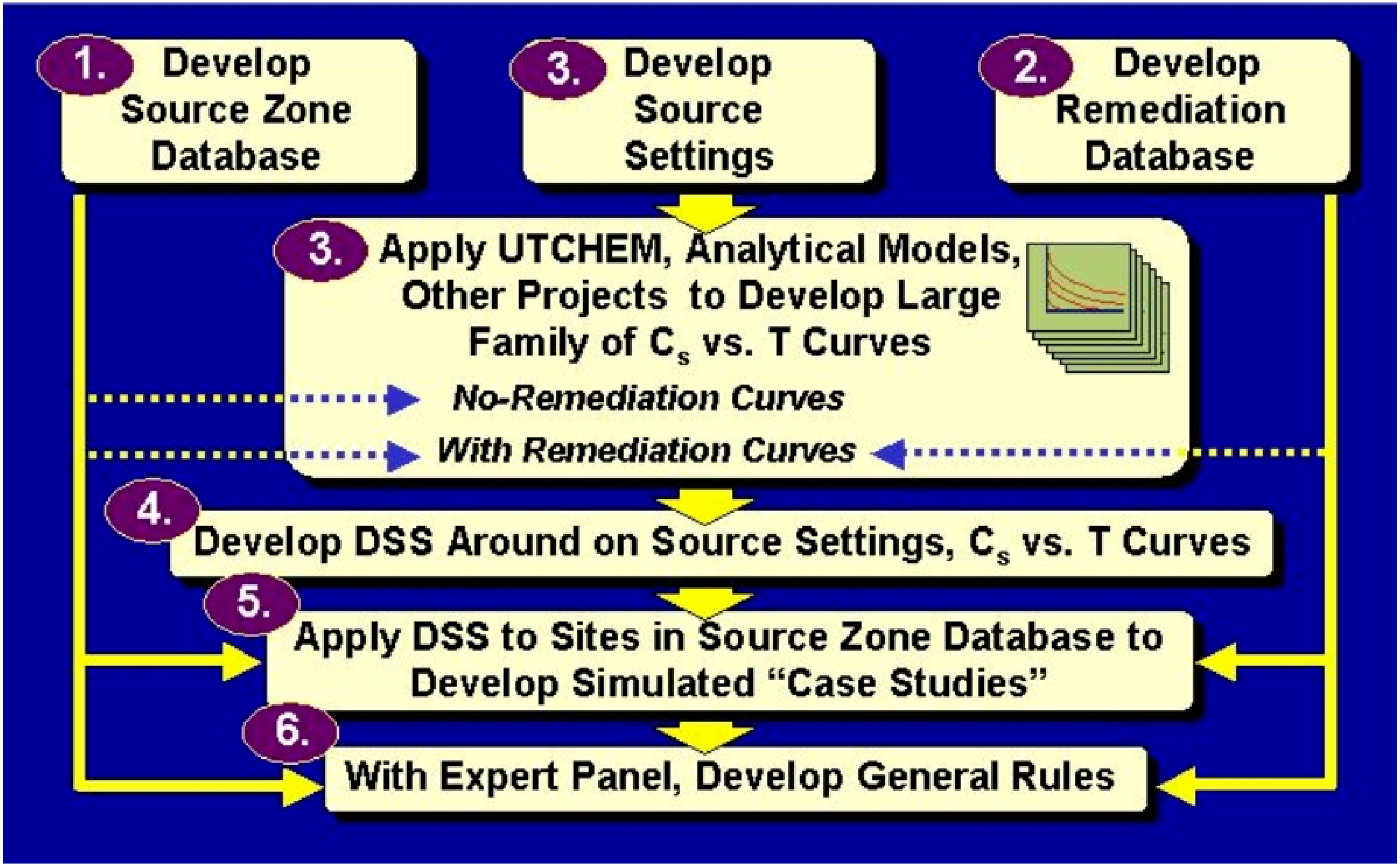
Enhanced Mass Transfer

K. Sorenson, NorthWind



Decision Support System: Source Treatment

C. Newell, Groundwater Services Inc.



QUESTIONS

- Is “Mass Flux” a Useful Metric?
- How Do We Handle the Uncertainty?
- What Advice Do We Give Now?

LESSONS FOR RPMs

- First, Do No Harm
- Keep It Simple, and Small
- Define Objectives <u>and</u> Metrics
- Consider Source Isolation
- Learn As You Burn